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References not used in the text are automatically deleted from this section of the project specification when you choose to reconcile references in the publish print process.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ELECTRONIC INDUSTRIES ALLIANCE (EIA)

EIA 359-A (1985) Standard Colors for Color Identification and Coding

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 (2007; AMD 1 2008) National Electrical Code - 2008 Edition

U.S. AIR FORCE (USAF)

TO 31W3-10-12 (1986) AF Communications Service Standard Installation Practices, Outside Plant Cable Placement

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FED-STD-595 (Rev B; Am 1) Colors Used in Government Procurement

1.2 GENERAL REQUIREMENTS

NOTE: If Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL and Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS is not included in the project specification, insert applicable requirements therefrom and delete the following paragraph.

Section 26 05 00.00 40 COMMON WORK RESULTS FOR ELECTRICAL and Section 26 00 00.00 20 BASIC ELECTRICAL MATERIALS AND METHODS apply to work specified in this section.

1.3 SYSTEM DESCRIPTION

Fiber optic cable must consist of optical fibers, strength member (or members), and jacketing. Associated components must include optical fiber connectors, optical patch panels, terminal bay cabinets, and splice closures. Fiber optic cables must be installed in inner duct in the existing cable duct and manhole system and/or directly buried to the facility. Locate fiber optic terminal in existing facility buildings.

All references in this section to cable must be deemed to mean fiber optic cable.

1.4 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project. Submittals should be kept to the minimum required for adequate quality control.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, use a code of up to three characters within the submittal tags following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that reviews the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Submit manufacturer's catalog data for the following items. Data must include a complete list of parts, special tools, and supplies with current unit prices and source of supply.

Optical Fibers
Fiber Optic Cable
Splice Case
Splice Organizers
Pre-Connectorized Cable Assembly
Fiber Optic Terminal Bay Cabinets
Optical Patch Panel

SD-06 Test Reports

Optical Fibers
Fiber Optic Cable
Pre-Connectorized Cable Assembly
Sequential Cable Markings
Single and Multi-mode OTDR Test
End-to-End Attenuation Tests
End-to-End Installed Bandwidth Cable Test

Submit contractor test reports for approval to the Technical Representative not later than 14 working days after the completion of each test.

Make manufacturing, or factory, tests and submit results to the Contracting Officer, for approval, prior to shipment of material to the site.

Sequential cable markings along the cable, prior to and after each end of splice point, must be recorded on the sequential cable form and submitted for approval.

Submit test results on all installed fiber cabling before and after each pre-connectorized cable assembly splice is completed.

Submit all test results prior to final testing.

End-to-End Attenuation Test reading must be included as the test reference loss as indicated.

End-to-End bandwidth cable test must be made at the completion of the testing.

SD-07 Certificates

Submit a **Quality Assurance Plan** for fiber optic cable systems consisting of detailed procedures defining methods to ensure compliance to contract drawings and specifications by drawing control, inspection and procurement records, test plan showing when and how each system is to be tested, material testing, and certification records. Submit test plan to the Technical Representative for approval at least 30 days prior to the start of testing.

PART 2 PRODUCTS

2.1 FIBER OPTIC CABLE DESIGN

Design of this cable must be in accordance with the requirements of cable specification 79K28125 except where noted.

All fiber must be of the same type, specification and manufacturer. Order of sequence of fibers in the cable is Multimode (MM) first and Single Mode (SM) last. Outer protection to the cable structure can be provided for building, direct burial, rodent or lightning conditions. Riser and plenum cable must be in accordance with **NFPA 70**, Article 770.

Primary protective coated **optical fibers**, both MM and SM, must be individually buffered with a color coded substance for individual fiber identification and ease in handling. Maximum outside diameter of the buffered fiber must be less than 300 micrometer. Fibers and the buffer

tubes must have pigmented inking formulas to provide vivid colors that can be distinguished rapidly. Type and size of the cable must be identified on the design plans. Each cable must contain multimode (MM) and/or single mode (SM) fibers in bundles within loose buffer tubes. In the fiber cable, the MM fibers are included with the SM fibers in a ratio of 1 to 1, 2 to 1, or 5 to 1.

Colors must be in accordance with EIA 359-A. Munsell Notation for pink must be 1R-4R 6.5-8.5/10 up and for aqua must be 2BG-8BG 6.5-8.5/6-10. Color code fibers in each loose buffer tube using ten standard vivid colors together with a white or black stripe to form additional color combinations in the eleventh position and above; as well as pink and aqua, as alternates, for position eleven and twelve, respectively, as follows:

Blue(Bl), orange(O), green(G), brown(Bn), slate(S), white(W), red(R), black(Bk), yellow(Y), violet(V), blue-white(Bl-W), or pink(P), orange-white(O-W), or aqua(A).

Loose buffer tubes must follow the same coloring as above and must continue with the colors of green-white (G-W), brown-white(Bn-W), slate-white(S-W), red-white(R-W), black-white(Bk-W), yellow-white(Y-W), and violet-white(V-W).

Where a black stripe is utilized in place of the white stripe, the last four colors above are:

White-black(W-Bk), red-black(R-Bk), yellow-black(Y-Bk), and violet-black (V-Bk).

Use a metallic armor where direct buried cable is specified for additional tensile strength, rodent protection and high crush and moisture resistance.

2.2 CABLE IDENTIFICATION SYMBOL

First of three lines on the ID symbol must employ the following 5 characters:

First Three Characters: First three characters (from left to right) must denote the number of active optical fibers in the cable.

Fourth Character: Fourth character must be a slash.

Last Three Characters: Last three characters must denote optical transmission windows which the optical fiber can support. These windows are defined as follows:

- a. An "A" must be indicated denoting a window at a wavelength of 850 nanometers (nm) with an attenuation of 4 dB/kilometer and a bandwidth of 800 MHz-kilometer. Character must be an "O" when these requirements are not met.
- b. A "B" must be indicated denoting a window at a wavelength of 1,300 nanometer with an attenuation of 1.0 dB/kilometer and a bandwidth of 1,000 MHz-kilometer. Character must be an "O" when these requirements are not met.
- c. A "C" must be indicated denoting a window at a wavelength of 1,550 nanometer with an attenuation of 0.7 dB/kilometer and a bandwidth of 1,000 MHz-kilometer for multimode and 0.4 dB/kilometer or less

for single mode. Character must be an "0" when these requirements are not met.

Two lower lines of the cable ID symbol must indicate multi-mode or single mode fibers, the cable number and the fiber count:

Example: 216/OBC Identifies the number of optical fibers (216) and the optical transmission window (OBC - see preceding paragraph).

FM05: 1-108 Identifies Multi-Mode Fiber Cable 05 with MM Fibers as numbered.

and FS05: 1-108 Identifies Single Mode Fiber Cable 05 with SM Fibers as numbered.

2.3 REPLACEMENT CABLE

In addition to the cable sections, provide a reel of each size and type of the manufacturer's furnished cable, not less than 0.5 kilometers.

2.4 SPLICE ORGANIZERS AND CLOSURES

Single mode or multi-mode fibers must be fusion spliced with a protective sleeve covering and stored in an organizer with a minimum of 450 millimeter 18 inches spare fiber in the buffer tubing and coiled. Single mode fibers must be spliced last in the splice tray.

Fiber splice must be completed in a stainless steel housing or equivalent splice case outer closure. A rigid plastic inner closure and an organizer assembly capable of holding (6) 12 or (6) 24 fiber protected splice trays as required.

Space between the inner and outer closures must be filled with encapsulating fluid. Factory drill end plates to fit the cable(s) outer diameter.

2.5 PRE-CONNECTORIZED CABLE ASSEMBLY

Supply a factory assembled pre-connectorized cable assembly to interface with the patch panel bulkhead feed-through receptacle. Fiber in the pre-connectorized cable assembly must be manufactured by the same specifications and manufacturer as in the multi-fiber cable. Both the cable assembly connector and the bulkhead receptacle must be manufactured by the same manufacturer. Supply and install dust caps for all terminated fibers.

Connector/cable interface on both the multimode and the single mode assemblies must withstand a tensile force of 110 Newton 25 pounds without detrimental affects on the loss characteristics of the fiber.

Before the pre-connectorized cable assemblies are shipped to KSC, a Contracting Officer's representative must visit the assembly and polishing site to inspect the assembly and quality control procedures as well as random samples of the finished assemblies.

2.5.1 Multimode

Connector and feed-through adapter (coupler) used to terminate and test the fibers must be the equivalent of the AT&T enhanced ST connector and coupling. Coupling must be made of metal and must be the bayonet/flange type. Connector must have a metal housing and a ceramic ferrule. Connector must be terminated utilizing heat cured epoxy on a three (3) meter length of multimode fiber jacketed as a single fiber cable. Each connector half must exhibit a loss of 0.5 dB or less. Additional manufacturers include 3M and Porta Systems.

2.5.2 Single Mode

Connector and feed-through adapter (coupler) used to terminate and test the fibers must be the equivalent of the AT&T enhanced ST connector and coupling. Coupling must be made of metal and must be the bayonet/flange type. Connector must have a metal housing and a ceramic ferrule. Connector must be PC polished finish and terminated utilizing heat cured epoxy on a three (3) meter length of single mode fiber jacketed as a single fiber cable. Each connector half must exhibit a loss of .5 dB or less. Return loss for each connector must be -30 dB or better. Additional manufacturers include 3M and Porta Systems.

2.6 OPTICAL PATCH PANEL ASSEMBLIES

All cable terminations must be made in optical patch panel assemblies. Patch panel assemblies must be the pre-assembled ["Optima Instrument"] [_____] chassis and associated rack-mounting hardware manufactured by the [Optima Enclosures] [_____] or equivalent.

To facilitate the transition between outside plant cable and the pre-connectorized cable assemblies, the fibers must be fusion spliced and housed in a [Celwave-Valtec] [_____] splice tray, [Part No. C0081377] [_____] or equivalent. Position splice tray in the optical patch panel assembly as indicated. Attenuation of the fusion splice is not to exceed 0.2 db. Fusion splice must be covered with a protective sleeve.

2.7 FIBER OPTIC TERMINAL BAY CABINETS

FOT cabinets must be [Optima Enclosure's "Optima Vertical Cabinet," Model No. R-771924R (front recess only)] [_____] , or equal. Cabinet's frame must consist of vertical and horizontal tubular aluminum extrusions with a minimum wall thickness of 3.81 millimeter 0.150 inches. Front to rear aluminum extruded corners must be at least 3.18 millimeter 0.125 inches in thickness. Rear door, top panel, and side panels must be a minimum of 1.3 millimeter 18 gage steel. Provide cabinet with 1.9 millimeter 14 gage steel, 7.14 millimeter 0.281 inches punched panel/chassis mounting rails permitting recessed installation of equipment. Place entry and exit holes as indicated. Dimensions of cabinet and associated cabinet hardware must be as noted.

Cabinet must be gray in color in accordance with FED-STD-595.

[Optima accessories needed for FOT cabinets:

1. Connection Kit HW-67 for adjoining cabinets
2. Doors:

Solid rear door, typical, Model No. D-7719nn

Plexiglas front door, typical, Model No. 2D-7719nn-K

"nn" is replaced by RH or LH, depending on location.
Specific door ordering information to be as indicated.]

PART 3 EXECUTION

3.1 INSTALLATION

Cable construction work must be performed by construction personnel who have had at least 3 years experience in placing cables in conduit, cable trays, and underground duct systems.

Fiber optic cable splices, terminations and testing must be made by journeymen cable splicers who have had a minimum of one year experience in splicing and terminating fiber optic cables.

Each individual who is to perform fiber optic cable splicing is required to perform a minimum of one acceptable sample splice and termination. Sample splices and terminations are not to be incorporated in the job.

Contractor must give a school of instruction in the presence of the Contracting Officer, or his representative, to all individuals who are to perform cable construction, splicing, inside installation, terminating and testing work on this job. This schooling must be comprised of a careful and detailed review of construction techniques, splicing work, and termination according to the various procedures specified for use on this job. The school is to ensure the journeymen are familiar and understand all aspects of material, equipment, techniques, and procedures related to this project. This school must consist of a minimum of eight hours of instruction. Instructors must have had a minimum of three years experience in the splicing or terminating of the types of cables on which they are performing the instruction.

3.2 FIBER SPLICES

Outside plant fiber splices must be fusion type and made along the fiber route where indicated. Splices must exhibit an insertion loss not greater than 0.2 dB. All splice measurements must be made at 1300 nanometer, plus or minus 5 nanometer. All splices must be mounted in trays. Number of splices must not be increased.

Completed fusion type splice must be covered with a protective sleeve (heat shrink type or approved equal) to restore the protective properties of the fiber coating and buffering. Deviations to the splice, location and pulling plan are permitted, if approved by the Contracting Officer.

All fiber colors must be continuous from end to end. No switching or staggering of color scheme within the cable at splice points is allowed. Splice fibers in order with multi-mode fibers identified first and single mode fibers at the end.

Bring cables out of the manhole in a controlled environment to perform the fiber fusion splice operation. Complete the splice by returning the cable to the manhole and routing the cable around the manhole interior in a neat and orderly manner such that the excess cable does not impede future entrance and utilization. Secure cable at regular intervals.

3.3 WORK IN MANHOLES AND CABLE VAULTS

Ensure that safe operating procedures are followed, work equipment is adequate, and personnel have received proper training. All atmospheric tests must be conducted by others prior to Contractor personnel entering a manhole or vault. Safety equipment must be inspected and approved by an authorized representative of the Contracting Officer.

Smoking is not permitted. A safe atmosphere must be positively determined.

Protect open manholes by fences, railings, signs, flags, or lights, as applicable. Removal of manhole covers must be performed by two men using hooks and employing proper lifting techniques. All manhole covers in the immediate vicinity of the duct system where work is to be performed must be removed to permit adequate ventilation.

Each time work is begun, remove or pump excessive water from the manhole vault or duct run, as required, prior to personnel entrance.

A manhole entry permit is required for every manhole entry. This permit will be issued by Environmental Health.

Perform vapor tests to ensure that the presence of explosive gases is below dangerous concentration levels less than 25 percent by volume.

Perform above environmental tests each time work is started or at the initial crew change and repeat in a time interval not to exceed 8 hours. When prolonged forced ventilation is required, the time interval for additional tests must not exceed two hours.

Two persons must be present during manhole operations: one man enters the manhole, the other must remain outside. The outside person must be equipped with a communication device to call for help if necessary.

When environmental tests indicate atmosphere is not safe, use blowers or ejectors to clear all manholes or cable vaults of vapors, fumes, and gases to a safe level.

Operate blowers or ejectors continuously while work is being performed and until work is completed.

Blowers or ejectors must not be placed in the manhole or cable vault but must be located on the surface at a distance not less than 1500 millimeter 5 feet from the open manhole or cable vault to assure a safe operating atmosphere.

Use ladders of the proper length and type (wood or fiberglass) for entry into manholes.

Locate all engine driven equipment downwind from manholes.

3.4 CABLE PLACEMENT

Survey the installation to determine obstacles to installation and the exact locations for cables and equipment to be installed. Any conditions that preclude installation of cables and equipment in the location shown on the contract drawings must be immediately reported to the Contracting Officer.

Prior to any excavation, obtain excavation permits in accordance with the contract schedule.

3.4.1 Buried Cable Installation

3.4.1.1 Cable Placement

Buried cable installation refers to the placement of cables directly in the ground without protection other than their own outer coverage jackets. Overall buried cable installation can include manholes and hand holes, for splicing, terminating and pull-through purposes.

Location of the cable splice overlaps to be as noted. Ensure that all cable ends are sufficiently long before cutting.

A 0.15 millimeter 6-mil thick orange color warning tape must be placed 300 millimeter 12 inches above the cable. Tape must contain 25 millimeter 1-inch high lettering with the words: "CAUTION! BURIED CABLE BELOW" every 1500 millimeter 5 feet along the tape.

3.4.1.2 Field Staking

When staking the cable plow or trench line, place stakes at least every 30.5 meter 100 feet in level country and more frequently in rolling country or in dense vegetation, so that the construction force can sight at least two successive stakes at all times. Place stakes at changes in direction, clearly stake the beginning and end of all turns. Where existing buried cable is encountered within 600 millimeter 2 feet of the proposed line, decrease the distance between stakes to a minimum of 3.05 meter 10 feet. When possible, project stakes above the vegetation along the line. When a road or other crossings are involved, place stakes at both extremes of the right-of-way.

Lateral Stake Placement. Use a stake, with the appropriate number or explanation noted on it, to show the location of the items listed below:

- a. Each caution point, such as underground utility crossings and culverts.
- b. Miscellaneous points, such as physical cable protection.
- c. Buried cable warning sign locations.

3.4.1.3 Method of Cable Placement

Method used in placing the cable depends on the exact location of the route, obstructions encountered, soil conditions, and topography of the route. Use method which best suits the local conditions and which produces the least amount of disturbance or damage to existing utilities and surrounding areas. Under certain conditions, combinations of placing methods can be advantageous. All direct buried cable must have a warning tape placed above it as indicated.

Depth of buried cable in soil measured from the top of the cable to the surface of the ground must be a minimum of 770 millimeter 30 inches, when crossing existing utilities, hand excavation must be accomplished no less than 1200 millimeter 4 feet on each side.

Be familiar with the characteristics and capabilities of the plow and other equipment used in the installation of buried cable plant.

3.4.1.4 Open Trench Method

PROCEDURE: When placing cable by the open trench method, observe the following:

- a. Ensure that the trench is free of all rock and debris.
- b. Cable is to be pulled from cable reel truck or dolly and placed in the trench by hand.
- c. Cable is to be placed in trench as soon as practical and backfilled immediately to avoid cave-in, and provide safe operational conditions.
- d. Detail an inspector to walk closely behind the cable reel dolly. Inspector must make sure that the cable lies flat on the trench bottom, and is placed at the required minimum depth. He must be familiar with the standard signals and must walk in a position where he can be clearly seen, so that placing operations can be stopped when necessary.
- e. Cable is to be pulled by hand on each end simultaneously, to remove excess slack, prior to backfilling.
- f. Trench is to be backfilled in 150 millimeter six-inch lifts to ensure proper fill. Compact each backfill lift with hand tamp tools. First lift is to be hand tamped prior to placing the cable.

3.4.1.5 Direct Plow Method

PROCEDURE: When placing cable by the direct plow method, observe the following:

- a. Ensure that the plow is clear of any obstruction which could damage cable. Insure all rollers on the tractor and on the plow turn freely and are properly located.
- b. Detail a man on the reel hand feeding the cable at all times to insure no damage is done to the cable due to excess tension.
- c. Detail an inspector to walk closely behind the plow. Inspector must inspect the cable for any blemish or damage, and insure a free and continuous flow of the cable from the reel to the plow. Inspector is to ensure that the cable is plowed at the minimum required depth. He must be familiar with the standard signals and must walk in a position where he can be clearly seen so that placing operations can be stopped when necessary.

3.4.1.6 Compaction

Following the plowing in or trenching of wire or cable, the plow slot must be compacted. The following method of compaction is recommended: Run the tractor track or tire along and immediately adjacent to both sides of the plow slot; fill in any ground depressions which could develop with earth to form a mound over the center of the plow slot; and then run the tractor tire over the center slot. Different soil conditions can warrant that

other methods of compaction be employed.

3.4.1.7 Handling and Care of Materials During Construction

It is most important that extreme care be exercised in handling materials during construction. As required, provide competent supervision on the plow at all times to ensure that the buried cable is fed through the plow into the ground at zero tension. Under no circumstances must tension be allowed to develop in the cable.

Whenever the plow is stopped, sufficient cable is to be unreeled to guard against sudden jerks when the plow is started.

Extreme caution must be exercised to ensure that the plow is not backed up while the blade is in the ground. Experience has shown that cable can be severely damaged by the plow backing up even a slight amount. During the plowing operation, the plow could strike a buried object or rock that stops the equipment and necessitate removal of the plow from the ground. If this occurs, the plow must be removed carefully without backing up. If it is necessary to back the plow, the cable must be uncovered a sufficient distance back from the plow for inspection by the Government to determine if there is any damage. Immediately report any damage to the Contracting Officer. Repair or replace damages as directed by the Contracting Officer.

3.4.2 Underground Cable Installation

Inner duct assignment of individual cables is shown on the contract drawings. Cables must not be placed in ducts other than those specified.

Exercise adequate care when handling and storing reels of cable to prevent damage to the cable. Cable with dents, flat spots, or other sheath distortions must not be installed.

3.4.2.1 Securing Cable

Immediately after cable placement, a permanent identification tag as indicated must be attached to visible cable sections. Check cables to ensure that the markings are intact.

Support and secure cables and equipment as indicated. Where the specific method of support is not shown, use adequate supports and fasteners to secure cables and equipment in position. Metallic supports and fasteners must have a corrosion resistant finish. Route all cables along the interior sides of manholes.

Two or more cable hooks are required per manhole.

Use clamps and Ty-Raps as necessary to properly secure the cable.

3.4.2.2 Bending

Use caution when bending cable to avoid kinks or other damage to the sheath. Bend radius must be as large as possible with a minimum of 250 millimeter 10 inches. Increase minimum radius when necessary to meet cable manufacturer's recommendation. Cables must not rest against the edge of the duct conduit mouth, the 770 millimeter 30-inch manhole opening or other sharp edges.

Cable must be pulled and spliced in the manner and at the locations

indicated.

3.4.2.3 Pulling

Attach pulling lines to both cable ends when cable is destined for bi-directional pull, and fitted with factory-installed pulling eyes as shown in TO 31W3-10-12. Cables not equipped with a pulling eye must have the pulling line attached to the cable end by means of a cable grip, installed as shown in TO 31W3-10-12. Core hitches must not be used.

Locate and align cable reels so that the cable is paid out from the top of the reel into the duct or conduit in a long, smooth bend without twisting. Cable must not be pulled from the bottom of the reel. Use a cable feeder guide of proper dimensions at the mouth to guide the cable into the duct or conduit.

Set up rigging at the pulling end so that the pulling line and cable exit on a line parallel with the duct or conduit to prevent either from rubbing against the edge or mouth. Cable ends must not be pulled around sheave wheels. When the sheave or pulley cannot be positioned to obtain sufficient cable end slack for proper racking and splicing with the pulling line attached to the end of the cable, a split cable grip can be used to obtain the necessary slack.

3.4.2.4 Lubricant

Use adequate pulling lubricant, ["Polywater" Lubricant F] [_____] or equal, to minimize pulling tension and prevent sheath damage when pulling cables into ducts and conduits. Apply lubricant to the cable sheath with a lubricator. When pulling has been completed, the exposed cable ends must be wiped clean of lubricant.

Lubricants must be certified by the lubricant manufacturer to be compatible with and intended for use with plastic-sheathed cables. Soap and grease type lubricants must not be used.

Carefully check all equipment and the pulling set to minimize interruptions once pulling begins. Cable must be pulled as far as possible without stopping until the required amount of the cable has been placed. When for any reason the pulling operation must be halted before the pull is completed, the tension of the pulling line must not be released. When pulling is resumed, overcome the inertia of the cable by increasing the tension in small steps a few seconds apart until the cable is in motion. Cable must be paid from the top of the reel by rotating the reel in the feed direction at the rate of pull. Cable must not be stripped off the reel by pulling.

3.4.2.5 Damage and Defects

It is the Contractor's responsibility to ensure by means of a tension monitoring device that the cable pulling procedures being used do not exceed the maximum pulling tension that can be applied to the cable to be pulled into a conduit section. Any damage to the cable due to exceeding the maximum tension requires a new cable furnished by the Contractor.

Carefully inspect cable for sheath defects or other irregularities as it is paid out from the reel. When defects are detected, stop pulling immediately and repair or replace the cable section at the discretion of the Contracting Officer. Maintain a system of communications between

pulling and feed locations so that pulling can be stopped instantly, when necessary.

When making pull-throughs, use a man in the intermediate manhole to guide the cable into the next duct section. Use proper rigging in the intermediate manhole to keep the pulling line and cable aligned with the exit duct to prevent the line or cable from rubbing against the edge of the duct. Cables in pull-through manholes must be set up and racked before the cable ends in adjacent manholes are set up and racked.

Cable ends pulled into manholes, vaults, or terminal locations that are not to be racked or otherwise permanently positioned immediately must be tied in fixed positions to prevent damage to the cables and provide adequate working space.

3.4.2.6 Seal

Ducts or innerduct in which cable is placed must be sealed with urethane foam duct seal. Insert this material between the cable and the duct or innerduct of which it is in, between the innerduct and the duct, and in all unused innerduct, in order to prevent damage to the cable sheath and to prevent the entrance of dirt or water into the manhole or vault.

Provide cables in continuous lengths as required to accomplish the required installation without splices from termination to termination, except where field splices are specifically shown.

3.4.3 Cabling Installation in Cable Trays

Communication cables must not be installed in the same cable tray with AC power cables.

Cables placed in cable trays must be installed in a neat and orderly manner and must not cross or interlace other cables except at breakout points.

Cables in vertical trays must be individually retained with [Ty-Rap] [_____] straps or equal, a maximum of 1800 millimeter 6 feet on center.

3.4.4 Cable Delivery

Deliver replacement cable reels to the Government as directed by the Contracting Officer.

3.5 GROUNDING SYSTEMS

Cables must be grounded at each termination point or as indicated.

3.6 TESTING

All test equipment, test procedures, and testing techniques must be specified in the quality assurance plan and require approval prior to execution. Tests must be conducted by the Contractor in accordance with the approved Quality Assurance Plan. Purpose of this testing is to verify that the installed fiber optic cable system meets all specified attenuation and bandwidth requirements and is capable of being used for its intended purpose. Field tests must be witnessed by the Government Technical Representative. Government Technical Representative must be given at least 20 working days notice prior to performing each test.

3.6.1 Quality Assurance Plan

Prepare a quality assurance plan which provides a detailed outline of all testing to be accomplished. Quality assurance plan must address whether cladding modes have been stripped prior to testing, source wavelength, peak, spectral width full width/half maximum (FWHM), mode structure, fiber end preparation, and bandwidth measurements of fiber links both greater and less than 1 kilometer. Quality assurance plan must include, as a minimum, a schedule of when tests must be performed relative to installation milestones, specific test procedure to be used, a list of test equipment to be used, manufacturer, model number, range, resolution accuracy, and must conform to the specified requirements of other sections of this specification.

3.6.2 OTDR Test

Perform Optical Time Domain Reflectometer (OTDR) tests during cable installation splice operations. Fiber alignment must be made according to the OTDR read out to minimize the loss as the fusion splice is completed. A 1 kilometer (minimum) fiber delay line is required between the OTDR and the first connector and after the far end. Splices not conforming with the maximum attenuation requirements must be reworked to conform. When after three attempts, the specified value is not obtained, complete the splicing operation with the approval of the Contracting Officer note on the test record. Perform testing in both directions.

3.6.3 Installed Signature

Provide an end-to-end signature trace for all completed fibers. Trace must show the entire cable loss including the fiber, all splices, cable assemblies and all delay lines. Base acceptance on maximum allowable loss through the patch panels of 1.2 dB for the mated pair of connectors and the panel splice.

3.6.4 End-to-End Attenuation Tests

After terminations have been completed, measure each fiber end-to-end from both directions. Measure attenuation at 1,300 nanometer (nominal) wavelength using the insertion-loss method with the power launched into a short reference fiber utilizing the same type connectors on each end. Reference fiber must be connected to the optical transmitter, wrapped around 12 millimeter 1/2 inch diameter mandrel 5 times as a minimum and connected to the same type connector as the system to be tested. A similar connector and short reference fiber must be connected to the power meter and the reference measured. Transmitter and power meter must be connected to opposite ends of the system to be tested. Also test attenuation for the 1550 nanometer wavelength.

Measured loss must be less than the calculated loss where the length under test in kilometers multiplied by 1 dB/kilometer added to the number of splices multiplied by .2 dB added to the number of connector halves multiplied by .5 dB for MULTIMODE and multiplied by only .5 dB/kilometer for SINGLE MODE fibers.

3.6.5 End-to End Bandwidth Tests (Multimode Only)

Measure end-to-end bandwidth utilizing the frequency domain method. Measure bandwidth in both directions. Bandwidth at -3 dB optical power of each optical fibers in the cable must be a bandwidth length product greater

than 1 GHz-kilometer within a peak optical emissive region of 1280-1330 nanometer. Make this test at the completion of all other testing. Calculated bandwidth in megahertz (MHz) must be equal to or greater than 1 GHz-kilometer for lengths less than 1 kilometer and must be equal to or greater than 1 GHz-kilometer divided by the length in kilometers for lengths greater than 1 kilometer.

3.6.6 Test Results

Each test sheet must have a sign-off blank for the Contractor as well as the Contract Technical Representative. Copies of the completed test forms or test results must be delivered according to the shop drawing procedure.

Maintain an accurate test record during all Field Tests. Samples are attached at the end of this section. Use of these sample formats are not mandatory.

3.7 TEST EQUIPMENT

Submit a [quality assurance plan](#).

Test equipment used for verifying installation testing must be calibrated by a certified testing company within three weeks of use and meet the following requirements.

3.7.1 Optical Time Domain Reflectometer (OTDR)

Operating wavelengths: 1,300, plus or minus 20 nanometers

Attenuation Range (one way): minimum 15 dB at 1,300 nanometer

Attenuation Resolution: 0.01 dB

Accuracy: plus 0.5 dB.

Display: OTDRs must have digital readout capability and must have a means of providing a permanent record, strip chart or photograph.

3.7.2 Attenuation Measurement Test Set

An attenuation measurement test set must consist of an optical power meter and an optical power source. Attenuation measurement test set must be traceable to NBS standards for stable optical source. Meter can be analog or digital. The following requirements must apply:

Operating wavelengths: 1,300, plus or minus 10 nanometers

Attenuation Range: at least 30 dB or better at 1,300 nanometer

Attenuation Resolution: 0.01 dB

Accuracy: Accuracy of the attenuation measurement test set must be plus or minus 5 percent.

Optical source must be capable of coupling sufficient power into the fiber so that the light received at the meter is within the meter detectability limits.

3.7.3 Bandwidth Measurement Equipment

Operating wavelengths: 1,300, plus or minus 10 nanometers

Bandwidth range: minimum 1000 megahertz

Bandwidth Resolution: 1 megahertz

Accuracy: plus or minus 0.5 megahertz

Measurement Method: Swept Frequency

FACTORY CABLE DATA (REELED)

[illegible]

CONTRACTING OFF. REP.: _____ DATE: _____

PRE-CONNECTORIZED CABLE ASSEMBLY

LENGTH: _____ km (_____ ft.) LOT NO. _____

[illegible]

CONTRACTING OFFICER'S REP.: _____ DATE: _____

SAMPLE DATA FORM

SEQUENTIAL CABLE MARKINGS

FROM BLDG.: _____ TO BLDG./END POINT: _____
 LENGTH: _____ km. CABLE NUMBER: _____

BUILDING /MANHOLE	LOCATION	READING	DISTANCE
	START POINT		
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
			km
	END POINT		km
TOTAL (START TO END)			km

TEST CONDUCTOR: _____ DATE: _____

CONTRACTING OFFICER'S REP.: _____ DATE: _____

SAMPLE DATA FORM

SINGLE AND MULTI-MODE OTDR TEST

1300nm	OTDR
PICTURE <div style="border: 1px solid black; height: 150px; width: 100%;"></div>	TEST LOCATION: _____ _____ SPLICE LOCATION: _____ _____ VERT.= _____ dB/div. HORZ.= _____ km/div. LENGTH TO SPLICE _____ km. LOSS TO SPLICE _____ dB. FIBER LENGTH TO END _____ km. FIBER LOSS TO END _____ dB. SPLICE LOSS _____ dB. TUBE _____ COLOR _____ CABLE NUMBER _____ FIBER COUNT _____

1300nm	OTDR
PICTURE <div style="border: 1px solid black; height: 150px; width: 100%;"></div>	TEST LOCATION: _____ _____ SPLICE LOCATION: _____ _____ VERT.= _____ dB/div. HORZ.= _____ km/div. LENGTH TO SPLICE _____ km. LOSS TO SPLICE _____ dB. FIBER LENGTH TO END _____ km. FIBER LOSS TO END _____ dB. SPLICE LOSS _____ dB. TUBE _____ COLOR _____ CABLE NUMBER _____ FIBER COUNT _____

TEST CONDUCTOR: _____ DATE: _____

CONTRACTING OFFICER'S REP.: _____ DATE: _____

END-TO-END ATTENUATION TEST

[illegible]

CONTRACTING OFFICER'S REP.: _____ DATE: _____

END-TO-END INSTALLED BANDWIDTH CABLE TEST REPORT

[illegible]

-- End of Section --